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SUSQUEHANNA RIVER BASIN
TRIBUTARY OF SNAKE CREEK, SUSQUEHANNA COUNTY
PENNSYLVANIA

WARNER DAM

NDI No. PA00975

PennDER No. 58-71

Dam Owner: William S. Newlin, Jr.

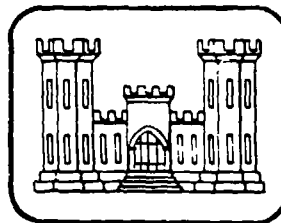
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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PA C W 31-81-C-0011



prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.

Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

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plates. All DTIC reproductions
will be in black and
white*

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AUGUST 1981

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PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Warner Dam, Susquehanna County, Pennsylvania
NDI No. PA 00975, PennDER No. 58-71
Tributary of Snake Creek
Inspected 30 March 1981

ASSESSMENT OF
GENERAL CONDITIONS

Warner Dam is owned by William S. Newlin, Jr., and is classified as a "Low" hazard - "Small" size dam. The dam was found to be in fair overall condition at the time of inspection.

Hydraulic/hydrologic evaluations performed in accordance with procedures established by the Baltimore District Corps of Engineers, for Phase I Inspection Reports, revealed that the spillway capacity is less than the peak inflow to the impoundment during the 100-year flood. A spillway design flood (SDF) in the range of the 50-year flood to the 100-year flood is required for Warner Dam. The 100-year flood was chosen as the SDF. The spillway is therefore considered "Inadequate." It is recommended that the owner immediately develop remedial measures to provide adequate spillway capacity.)

> The inspection revealed certain items of remedial work which should be performed by the owner without delay. These include:

- > (1) Provide adequate spillway capacity;
- > (2) Repair the spalling on the downstream face of the concrete corewall;
- > (3) Ensure that the outlet works are operable, or develop an emergency drawdown plan; and
- > (4) Cut all trees on the embankment at ground level. All trees with a trunk diameter greater than 3 inches should have their root systems removed. All resultant areas of erosion and cavities should be filled, graded, compacted and seeded.)

> In addition, the following operational measures are recommended to be undertaken by the owner: -> see page

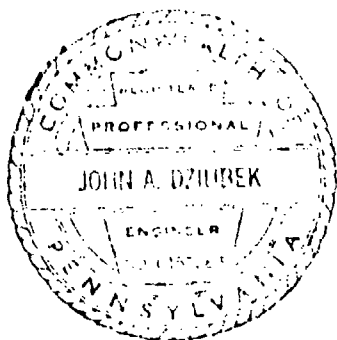
WARNER DAM

- cont →
- (1) Develop a detailed emergency operation and warning system;
 - (2) During periods of unusually heavy rainfall, provide around-the-clock surveillance of the dam; and
 - (3) When warning of a storm of major proportions is given by the National Weather Service, activate the emergency operation and warning system. ←

It is further recommended that formal inspection, maintenance, and operational procedures and records be developed and implemented. These should be included in a formal maintenance and operations manual for the dam.

Submitted by:

MICHAEL BAKER, JR., INC.



John A. Dziubek
John A. Dziubek, P.E.
Engineering Manager-Geotechnical

Date: 20 August 1981

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

James W. Peck
JAMES W. Peck
Colonel, Corps of Engineers
District Engineer

Date: 31 Aug 81

WARNER DAM



Overall View of Dam Crest From Left Abutment



Overall View of Downstream Face of Dam From Left Abutment

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
WARNER DAM
NDI No. PA 00975, PennDER No. 58-71
SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.
- b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances - Warner Dam is an earthfill embankment 161 feet long and 13.1 feet high with a vertical stone masonry downstream face. The embankment has a crest width of 22 feet, and its upstream face has a side slope of 3.7H:1V (Horizontal to Vertical). The wall forming the downstream face of the dam extends 3 feet above the crest of the dam.

The spillway is a concrete rectangular channel 40 feet long and 8 feet wide located near the center of the dam. There is an 11-foot long stone arch walkway over a portion of the channel. There is 1.3 feet of clearance between the bottom of the channel and the bottom of the walkway. The spillway passes through an opening in the stone wall along the downstream face of the dam, which is 15 square feet in size. The flow then cascades to a concrete paved discharge channel and to the rock lined downstream channel.

The auxiliary spillway is located at the right abutment. The approach to the auxiliary spillway is a well-vegetated open channel. The spillway is a rectangular channel which is covered by an arched masonry walkway. There is 1 foot of clearance between the channel bottom and the bottom of the walkway. Flow from the spillway is carried downstream by a grass lined trapezoidal channel.

The outlet works for the dam consist of an 8-inch cast iron pipe beneath the spillway channel. There is a valve on the upstream end of the pipe.

- b. Location - Warner Dam is located on an unnamed tributary of Snake Creek, approximately 1.8 miles northeast of Montrose, Pennsylvania. The dam is located in Bridgewater Township, Susquehanna County, Pennsylvania. The coordinates of the dam are N 41° 51.2' and W 75° 50.8'. The dam and reservoir are shown on the USGS 7.5 minute topographic quadrangle, Montrose East, Pennsylvania.
- c. Size Classification - The height of the dam is 13.1 feet. Storage at the top of the dam [Elevation 1591.5 feet Mean Sea Level (ft. M.S.L.)] is 106 acre-feet. Therefore, the dam is in the "Small" size category.
- d. Hazard Classification - There is one home, a shed and a barn located 5 to 10 feet above the streambed, 2600 feet downstream from the dam, which may suffer economic damage if the dam were to fail; however, no loss of life is believed likely to occur. Therefore, Warner Dam is considered to be in the "Low" hazard category.
- e. Ownership - The dam and reservoir are owned by William S. Newlin, Jr., 1114 Ivy Mont Road, Rosemont, Pennsylvania 19010.
- f. Purpose of Dam - The reservoir is used for recreation.
- g. Design and Construction History - The designer and construction date are unknown. The stone wall on the downstream face of the dam was raised in 1930.
- h. Normal Operational Procedures - The dam is normally maintained at or near the spillway crest, elevation 1590.0 ft. M.S.L.

1.3 PERTINENT DATA

- a. Drainage Area (square miles) - 0.34
- b. Discharge at Dam Site (c.f.s.) -
- Maximum Flood - Unknown
- Spillway Capacity at Maximum Pool (El. 1591.5 ft. M.S.L.) - 50.0

- c. Elevation* [feet above Mean Sea Level (ft. M.S.L.)] -
- | | |
|-------------------------------|---------|
| Design Top of Dam - | Unknown |
| Minimum Top of Dam - | 1591.5 |
| Maximum Design Pool - | Unknown |
| Spillway Crest - | 1590.0 |
| Streambed at Toe of Dam - | 1578.4 |
| Maximum Tailwater of Record - | Unknown |
- d. Reservoir (feet) -
- | | |
|---|--------|
| Length of Maximum Pool
(El. 1591.5 ft. M.S.L.) - | 2000.0 |
| Length of Normal Pool
(El. 1590.0 ft. M.S.L.) - | 1900.0 |
- e. Storage (acre-feet) -
- | | |
|---------------------------------------|-------|
| Top of Dam (El. 1591.5 ft. M.S.L.) - | 106.0 |
| Normal Pool (El. 1590.0 ft. M.S.L.) - | 80.0 |
- f. Reservoir Surface (acres) -
- | | |
|---------------------------------------|------|
| Top of Dam (El. 1591.5 ft. M.S.L.) - | 18.4 |
| Normal Pool (El. 1590.0 ft. M.S.L.) - | 16.5 |
- g. Dam -
- | | |
|--|-----------|
| Type - | Earthfill |
| Total Length (feet) - | 161.0 |
| Height (feet) - Design - | Unknown |
| Field - | 13.1 |
| Top Width (feet) - | 22.0 |
| Side Slopes - Upstream - | 3.7H:1V |
| Downstream - | Vertical |
| Zoning - | Unknown |
| Impervious Core - A concrete wall forms the
downstream face | |
| Cut-off - | Unknown |
| Drains - | Unknown |
- h. Diversion and Regulating Tunnels -
- | | |
|--|------|
| | None |
|--|------|

*All elevations are referenced to the spillway crest, El. 1590.0 ft. M.S.L., as estimated from the USGS 7.5 minute topographic quadrangle, Montrose East, Pennsylvania.

i. Spillway -

Type - Concrete rectangular channel

Location - Center of embankment

Length of Crest Perpendicular to

Flow (feet) -

8.0

Crest Elevation (ft. M.S.L.) -

1590.0

Gates -

None

Downstream Channel -

Rock lined

j. Auxiliary Spillway -

Type - Rectangular channel

Location - Right abutment

Length of Crest Perpendicular to

Flow (feet) -

7.0

Crest Elevation (ft. M.S.L.) -

1590.8

Gates -

None

Downstream Channel -

Grass lined

- k. Outlet Works - An 8-inch cast iron pipe beneath the spillway channel with a valve on the upstream side of the dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data is available for review concerning the Warner Dam. The only information available is File No. 58-71 of the Pennsylvania Department of Environmental Resources (PennDER). This file included:

- 1) Information survey sheet of the dam, dated 10 November 1919.
- 2) Inspection report filed with the Division of Dams and Encroachments stating that the dam is in good condition, dated 24 August 1965.

2.2 CONSTRUCTION

The owner's representative indicated the dam had been built sometime between 1900 and 1919. The wall on the downstream face of the dam was raised in 1930.

2.3 OPERATION

No formal procedures are followed for operation of the dam and reservoir. The spillway is uncontrolled and the reservoir is normally at the spillway crest level.

2.4 ELEVATION

- a. Availability - The information used is readily available from PennDER File No. 58-71.
- b. Adequacy - The information available, combined with the visual inspection measurements and observations, is adequate for a Phase I Inspection of this dam.
- c. Validity - There is no reason at the present time to doubt the validity of the available engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - The dam was found to be in fair overall condition at the time of the inspection on 30 March 1981. No unusual weather conditions were experienced during the inspection. Noteworthy deficiencies observed during the visual inspection are described briefly in the following paragraphs. The complete visual inspection checklist, field sketch, top of dam profile, and typical cross-section are presented in Appendix A.
- b. Embankment - The downstream face of the concrete core wall is spalling. There are some trees growing near the downstream toe of the embankment. A wet marshy area was located at the right downstream side of the embankment due to poor surface drainage of the area.
- c. Appurtenant Structures - The valve for the outlet works has not been operated since the 1960's. No problems were observed.
- d. Reservoir Area - The reservoir slopes are gentle and no signs of instability were observed. A small amount of sedimentation has occurred at the upper end of the reservoir, according to the owner's representative.
- e. Downstream Channel - The channel has mild slopes and passes through a 4 foot diameter culvert under a township road approximately 1000 feet downstream from the dam. One home, a shed and a barn are located 2600 feet downstream from the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal procedures for operating the reservoir or evacuating the downstream area in case of an emergency. It is recommended that formal emergency procedures be adopted, prominently displayed and furnished to all operating personnel.

4.2 MAINTENANCE OF DAM

There are no formal records of maintenance or formal procedures for evaluating the necessity of maintenance for the structure. It is recommended that formal inspection procedures be developed.

4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance is unscheduled. It is recommended that a formal operation and preventive maintenance schedule be developed and implemented. The operability of the outlet control valve was not known and should be checked and restored to a good operable condition or an alternate plan for the drawdown of the reservoir developed.

4.4 DESCRIPTION OF ANY WARNING SYSTEM

There is no warning system in the event of dam failure. It is recommended that an emergency warning system be developed.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The current operational features are adequate for the purpose they serve. However, it is recommended that a formal maintenance and operations manual be prepared for the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data - No hydrologic or hydraulic design calculations are available for Warner Dam.
- b. Experience Data - The owner's representative indicated the maximum depth which he had seen in the spillway was 3 inches, which is a flow of 6 c.f.s.
- c. Visual Operations - During the visual inspection, no problems were observed which would indicate that the dam and appurtenant facilities could not perform satisfactorily during a flood event.
- d. Overtopping Potential - Warner Dam is a "Small" size - "Low" hazard dam requiring evaluation for a spillway design flood (SDF) in the range of the 50-year flood to the 100-year flood. The 100-year flood was chosen as the SDF.

Using material from "The Hydrologic Study - Tropical Storm Agnes" prepared by the Corps of Engineers, New York District, the peak inflow to the impoundment for the 100-year flood was calculated to be 605 c.f.s. The peak inflow to the impoundment for the 100-year flood was also calculated to be 54 c.f.s., using material from "Water Resources Bulletin, Bulletin No. 13, Floods in Pennsylvania", prepared by the Department of Environmental Resources, Commonwealth of Pennsylvania. Averaging these two methods produced a peak inflow of 330 c.f.s. which was used in this analysis.

The spillway capacity at the minimum top of the dam is 50 c.f.s., which is approximately 16 percent of the peak inflow to the impoundment.

- e. Spillway Adequacy - As outlined in the above analysis, the inflow to the impoundment during the 100-year flood is greater than the spillway capacity; therefore, the spillway is considered "Inadequate".

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - There were no structural inadequacies noted during the visual inspection that cause concern for the continued structural stability of the dam.
- b. Design and Construction Data - Calculations of slope and structural stability were not available for review. The slopes have had a history of satisfactory performance. In view of the modest height of the dam, the history of satisfactory performance of the slopes, and no signs of distress observed during the visual inspection, a stability analysis is not deemed necessary.
- c. Operating Records - Nothing in the operational information was interpreted as cause for concern relative to the structural stability of the dam.
- d. Post-Construction Changes - No changes adversely affecting the structural stability of the dam have been performed.
- e. Seismic Stability - The dam is located in Seismic Zone 1 of the "Seismic Zone Map of the Contiguous United States", Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams." This is a zone of minor seismic activity. Therefore, further consideration of the seismic stability is not warranted since the dam is considered to be structurally stable.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety - Warner Dam was found to be in fair overall condition at the time of inspection. Warner Dam is a "Low" hazard - "Small" size dam requiring a spillway capacity in the range of the 50-year flood to the 100-year flood. The 100-year flood was chosen as the SDF. As presented in Section 5, the spillway capacity is less than the peak inflow to the impoundment during the 100-year flood. Therefore, the spillway is considered "Inadequate."
- b. Adequacy of Information - The information available and the observations and measurements made during the field inspection are considered sufficient for this Phase I Inspection Report.
- c. Urgency - The owner should immediately initiate the action discussed in paragraph 7.2.
- d. Necessity for Additional Data/Evaluation - The hydraulic/hydrologic analysis performed in connection with this Phase I Inspection Report has indicated the need for additional spillway capacity.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection revealed certain items of remedial work which should be performed by the owner without delay. These include:

- 1) Provide adequate spillway capacity.
- 2) Repair the spalling on the downstream face of the concrete core wall.
- 3) Ensure that the outlet works are operable, or develop an emergency drawdown plan.
- 4) Cut all trees on the embankment at ground level. All trees with a trunk diameter greater than 3 inches should have their root systems removed. All resultant areas of erosion and cavities should be filled, graded, compacted and seeded.

In addition, the following operational measures are recommended to be undertaken by the owner:

- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rainfall, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, activate the emergency operation and warning system.

It is further recommended that formal inspection, maintenance, and operational procedures and records be developed and implemented. These should be included in a formal maintenance and operations manual for the dam.

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APPENDIX A

VISUAL INSPECTION CHECK LIST, FIELD SKETCH,
TOP OF DAM PROFILE, AND TYPICAL CROSS-SECTION

(

Check List
Visual Inspection
Phase 1

Name of Dam Warner Dam County Susquehanna State Pennsylvania Coordinates Lat. N 41°51.2'
 NDI #PA 00975 Long. W 75°50.8'
 Pennder #58-71

Date of Inspection 30 March 1981 Weather Cloudy, rain Temperature 60° F.

Pool Elevation at Time of Inspection 1590.1 ft.* M.S.L. Tailwater at Time of Inspection ft. 1578.4 M.S.L.

*All elevations referenced to the spillway crest, El. 1590.1 ft. M.S.L., as estimated from USGS 7.5 minute topographic quadrangle, Montrose East, Pennsylvania.

Inspection Personnel:

Michael Baker, Jr., Inc.:

James G. Uliniski
 Jeff L. Sawyer
 Gary W. Todd

Owner's Representatives:

Gary Matthews - Caretaker for
 the Warner Estate

James G. Uliniski Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: WARNER DAM
NDI #PA 00975

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

LEAKAGE

STRUCTURE TO
 ABUTMENT/EMBANKMENT
 JUNCTIONS

DRAINS

WATER PASSAGES

FOUNDATION

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: WARNER DAM
NDI #PA 00975

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS
 CONCRETE SURFACES

STRUCTURAL CRACKING

VERTICAL AND HORIZONTAL
 ALIGNMENT

MONOLITH JOINTS

CONSTRUCTION JOINTS

EMBANKMENT

Name of Dam WARNER DAM
NDI #PA 00975

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS	None observed	
----------------	---------------	--

UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
---	---------------	--

SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed	
--	---------------	--

EMBANKMENT

Name of Dam WARNER DAM

NDI #PA 00975

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Good vertical and horizontal alignment. The downstream face of the corewall is spalled.	Repair spalling on corewall.
---	---	------------------------------

RIPRAP FAILURES	None observed
-----------------	---------------

VEGETATION	Some trees are growing near the downstream toe of the embankment.	Cut all trees within 10 ft. of the toe of the embankment. Remove root systems of all trees with a trunk diameter greater than 3 inches. Fill resulting cavities and seed.
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EMBANKMENT

Name of Dam WARNER DAM
NDI #PA 00975

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition	

ANY NOTICEABLE SEEPAGE

A wet marshy area was located at the right downstream side of the embankment. This area is due to poor surface drainage.

STAFF GAGE AND RECORDER

None observed

DRAINS

None observed

OUTLET WORKS

Name of Dam: WARNER DAM
NDI #PA 00975

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

CRACKING AND SPALLING OF
CONCRETE SURFACES IN
OUTLET CONDUIT

8 in. cast iron drawdown pipe.
No problems observed.

INTAKE STRUCTURE

The intake structure was submerged
at the time of inspection.

OUTLET STRUCTURE

No problems observed.

OUTLET CHANNEL

No problems observed.

EMERGENCY GATE

Type unknown - last operated in the
1960's.

UNGATED SPILLWAY

Name of Dam: WARNER DAM

NDI #PA 00975

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

Good condition

CONCRETE WEIR

APPROACH CHANNEL

No problems observed.

DISCHARGE CHANNEL

No problems observed. Lined
with rock fragments.

BRIDGE AND PIERS

A low stone arch walkway passes
over the approach channel.

AUXILIARY SPILLWAY

Name of Dam: WARNER DAM
NDI #PA 00975

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

CONCRETE WEIR

None

APPROACH CHANNEL

Grass lined approach channel.

DISCHARGE CHANNEL

Grass lined discharge channel.

BRIDGE AND PIERS

A low stone arch walkway passes over the spillway channel.

INSTRUMENTATION

Name of Dam: WARNER DAM
NDI #PA 00975

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
MONUMENTATION/SURVEYS	None observed	
OBSERVATION WELLS	None observed	
WEIRS	None observed	
PIEZOMETERS	None observed	
OTHER	None	

RESERVOIR

Name of Dam: WARNER DAM
NDI #PA 00975

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
------------------------------	---------------------	-----------------------------------

SLOPES

Gentle slopes (5° - 10°) with
good ground cover of woods.

SEDIMENTATION

The upper area of the reservoir is
reported to be only 3 ft. deep, but
it is not known how deep it was
originally.

DOWNSTREAM CHANNEL

Name of Dam: WARNER DAM

NDI #PA 00975

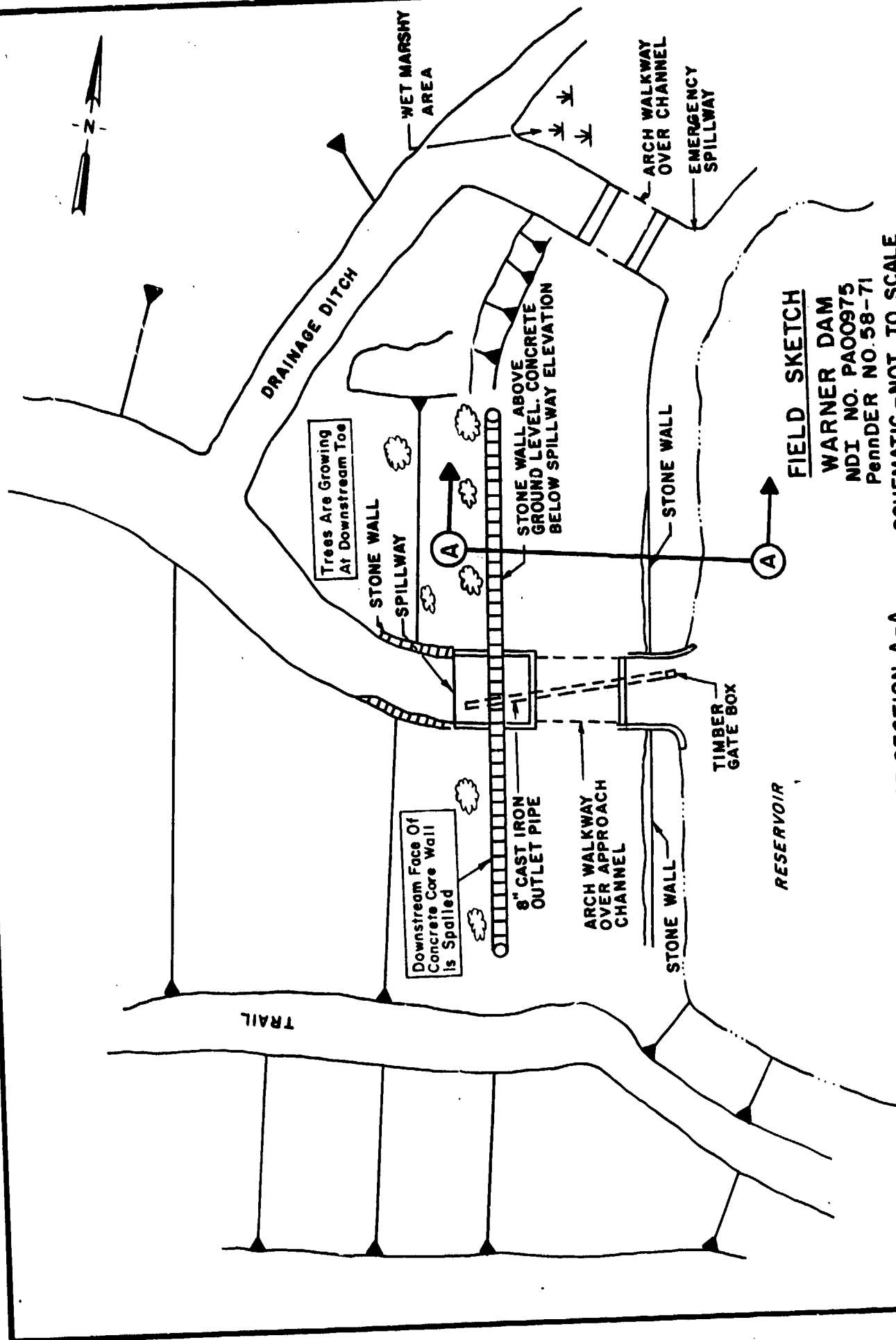
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No debris was present in the channel. Approximately 1000 ft. downstream channel passes through a 4 ft. diameter culvert under the township road.	

SLOPES

Mild slopes with good ground cover.

APPROXIMATE NO.
OF HOMES AND
POPULATION

One home is located 2600 feet downstream from the dam. This home is approximately 5 to 8 ft. above the streambed.



FIELD SKETCH

WARNER DAM

NDI NO. PA00975

PENNER NO. 58-71

SCHEMATIC - NOT TO SCALE

CROSS SECTION TAKEN AT SECTION A-A

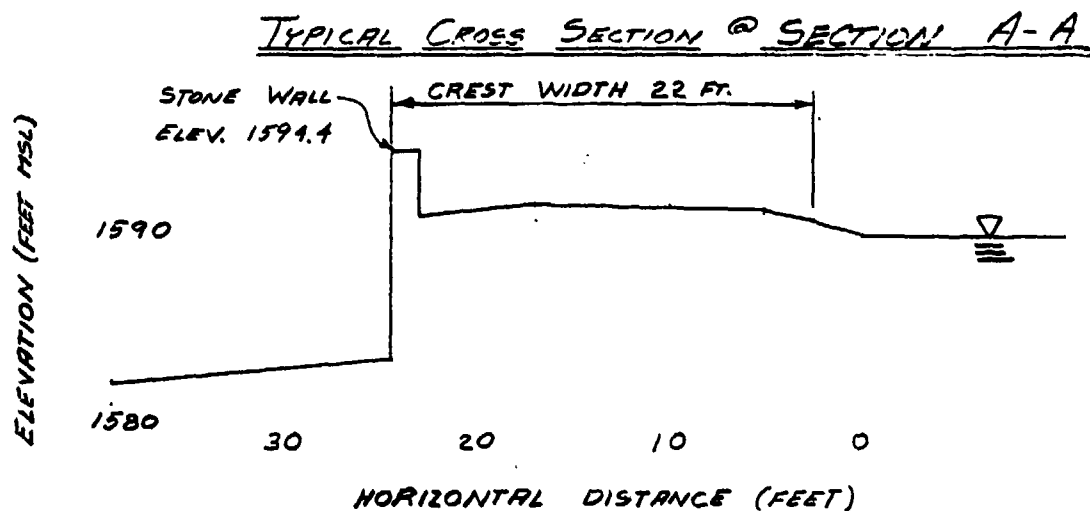
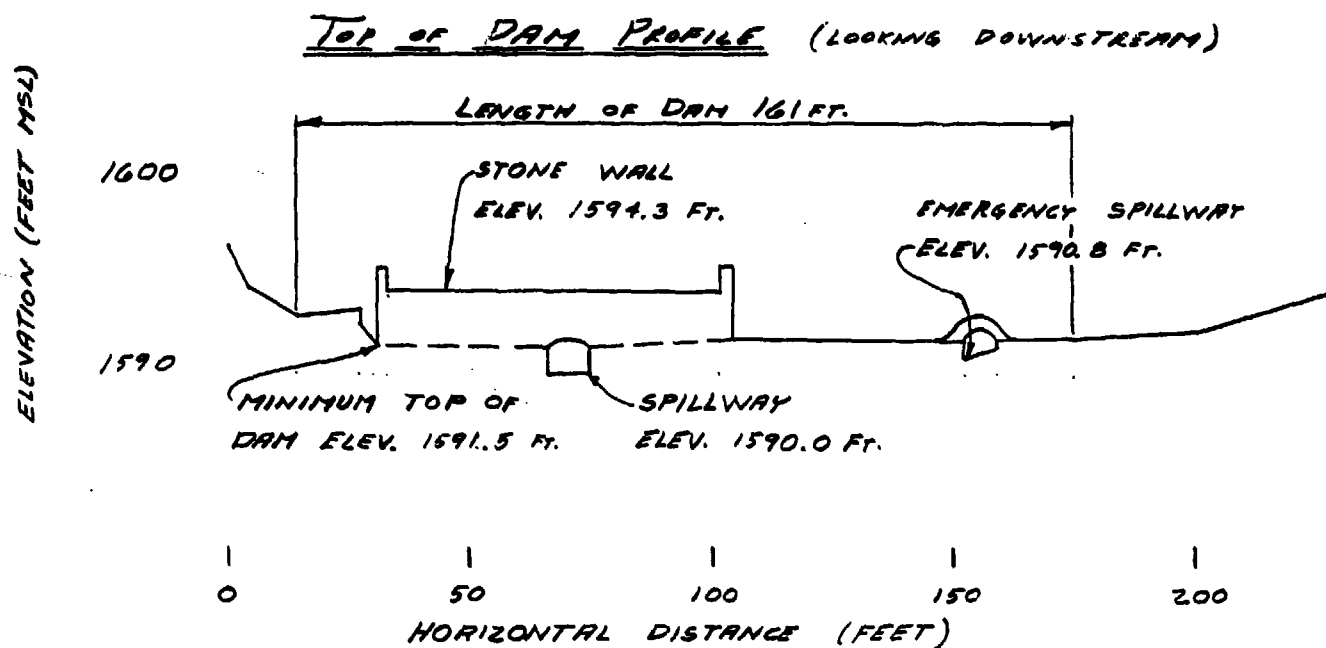
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

WARNER DAM

Box 280
Beaver, Pa. 15009

TOP OF DAM PROFILE
TYPICAL CROSS-SECTION

DATE OF INSPECTION: 30 March 1981



APPENDIX B

ENGINEERING DATA CHECK LIST

**CHECK LIST,
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION**

Name of Dam: Warner Dam
NDI #PA 00975

ITEM	REMARKS
PLAN OF DAM	None available, see Plate 3 for field sketch.
REGIONAL VICINITY MAP	A USGS 7.5' topographic quadrangle, Montrose East, Pennsylvania, was used to prepare the vicinity map which is enclosed in this report as the Location Plan (Plate 1).
CONSTRUCTION HISTORY	The dam was built sometime between 1900 and 1919. No other information is available.
TYPICAL SECTIONS OF DAM	None available, see Plate 4 for inspection cross section.
HYDROLOGIC/HYDRAULIC DATA	None available.
OUTLETS - PLAN	None available.
- DETAILS	None available.
- CONSTRAINTS	None available.
- DISCHARGE RATINGS	None available.
RAINFALL/RESERVOIR RECORDS	None available.

Name of Dam: WARNER DAM
 NDI #PA 00975

REMARKS

ITEM

None available.

DESIGN REPORTS

No geology reports are available for the dam. See Appendix F for regional geology.

GEOLOGIC REPORTS

No design computations are available.

DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES

No information available.

MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD

None performed.

POST-CONSTRUCTION SURVEYS OF DAM

No information available.

BORROW SOURCES

Name of Dam: WARNER DAM
NDI #PA 00975

B-3

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	The stone wall on the downstream face of the dam was raised in 1930.
HIGH POOL RECORDS	The owners' representative reported the maximum flow through the spillway has been 3 inches which is 6 C.F.S.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	No formal records of maintenance are kept.

Name of Dam: WARNER DAM
NDI #PA 00975

B-4

ITEM	REMARKS
------	---------

SPILLWAY PLAN,	No information available.
----------------	---------------------------

SECTIONS,
and
DETAILS

OPERATING EQUIPMENT
PLANS & DETAILS

No information available.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 0.34 sq. mi. (primarily pasture
and forests)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1590.0 ft. M.S.L.
(80 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1591.5 ft. M.S.L.
(106 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1591.5 ft. M.S.L. (minimum top of dam)

SPILLWAY: _____

- a. Crest Elevation 1590 ft. M.S.L.
- b. Type Rectangular channel
- c. Width of Crest Parallel to Flow 11 ft.
- d. Length of Crest Perpendicular to Flow 8.0 ft.
- e. Location Spillover Left center of dam
- f. Number and Type of Gates None

AUXILIARY SPILLWAY: _____

- a. Crest Elevation 1590.8 ft. M.S.L.
- b. Type Rectangular channel
- c. Length of Crest Perpendicular to Flow 7.0 ft.
- d. Location Spillover Right abutment
- e. Number and Type of Gates None

OUTLET WORKS: _____

- a. Type 8-in. cast iron pipe
- b. Location Below spillway
- c. Entrance Inverts Unknown
- d. Exit Inverts 1583.9 ft. M.S.L.
- e. Emergency Drawdown Facilities 8-in. cast iron pipe

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: Unknown

APPENDIX C
PHOTOGRAPH LOCATION PLAN AND PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View of Dam

Top Photo - Overall View of Dam Crest from Left Abutment
(OV-T)

Bottom Photo - Overall View of Downstream Face of Dam
(OV-B) from Left Abutment

Photograph Location Plan

Photo 1 - View of Upstream Face of Dam from Right Abutment

Photo 2 - View of Spillway Entrance

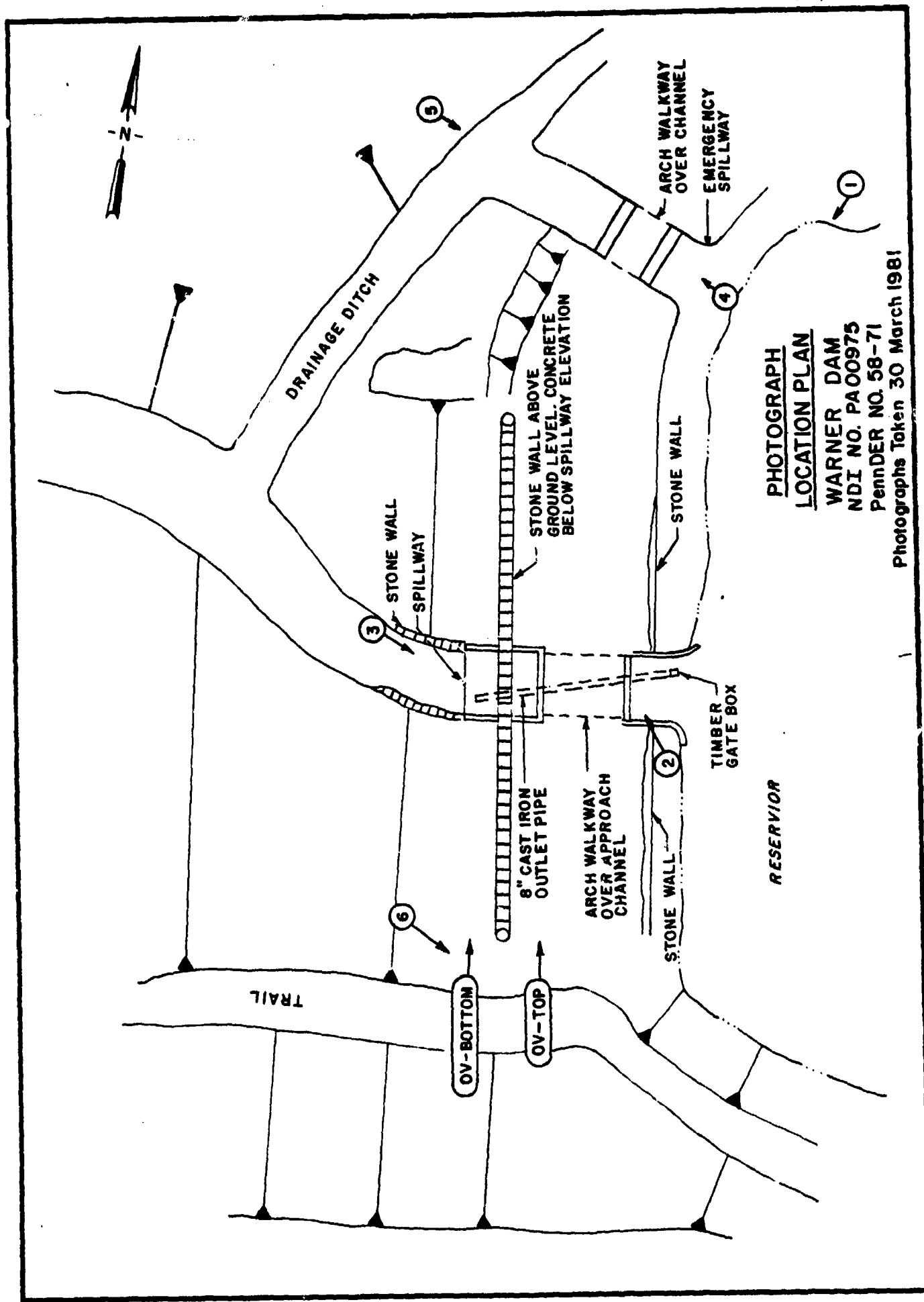
Photo 3 - View of Spillway Discharge and Outlet Pipe

Photo 4 - View of Entrance to Emergency Spillway

Photo 5 - View of Downstream Side of Emergency Spillway

Photo 6 - View of Emergency Spillway Discharge Channel at
Right Downstream Side of Dam

Note: Photographs were taken on 30 March 1981.



WARNER DAM
NDI NO. PA00975
PENNDER NO. 58-71

Photographs Taken 30 March 1981

WARNER DAM

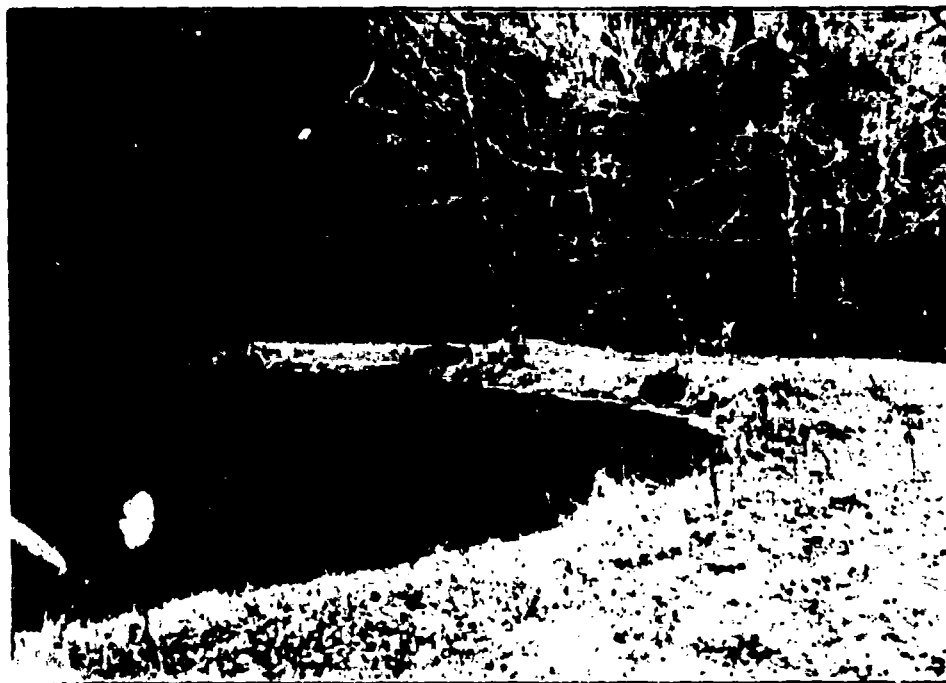


PHOTO 1. View of Upstream Face of Dam From Right Abutment



PHOTO 2. View of Spillway Entrance

WARNER DAM



PHOTO 3. View of Spillway Discharge and Outlet Pipe

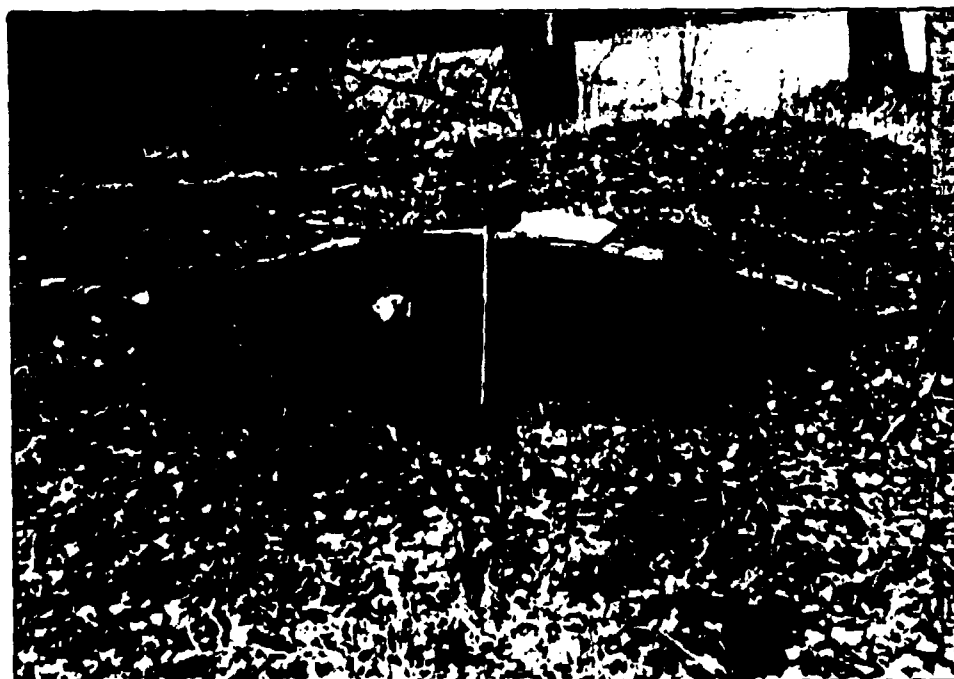


PHOTO 4. View of Entrance to Emergency Spillway

WARNER DAM



PHOTO 5. View of Downstream Side of Emergency Spillway



**PHOTO 6. View of Emergency Spillway Discharge Channel at
Right Downstream Side of Dam**

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject WARNER DAM S.O. No. _____
APPENDIX D- HYDROLOGIC AND Sheet No. _____ of _____
HYDRAULIC CALCULATIONS Drawing No. _____
Computed by _____ Checked by _____ Date _____

<u>SUBJECT</u>	<u>PAGE</u>
PREFACE	2
HYDRAULIC DATA	1
DRAINAGE AREA AND CENTROID MAP	2
TOP OF DAM PROFILE AND CROSS SECTION	3
SPILLWAY DISCHARGE RATING	4
AUXILIARY SPILLWAY DISCHARGE RATING	6
SPILLWAY DISCHARGE RATING SUMMARY	8
100- YEAR DISCHARGE CALCULATION	9

PREFACE

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

Conclusions presented herein pertain to present conditions. The effect of future development on the hydrology of the watershed has not been considered.

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Pa. Dam Insp.

Warner Dam

Hydraulic Data

Computed by GBD

Checked by GWT

S.O. No. 13837-00-ARA-

Sheet No. 1 of 10

Drawing No. _____

Date 4/13/81

DRAINAGE AREA

MONTROSE EAST QUAD. - $650.13/3 = 216.71$ Acres = 0.34 mi.^2

SURFACE AREAS

LAKE SURFACE @ El. 1590 - $0.54/3 = 0.18 \text{ in}^2 = 16.53$ Acres
El. 1600 - $0.94/3 = 0.31 \text{ in}^2 = 28.77$ Acres
El. 1620 - $1.58/3 = 0.53 \text{ in}^2 = 48.36$ Acres

WATERSHED LENGTHS

$L = 4,750 \text{ Ft.} = 0.90 \text{ mi.}$

$L_c = 1,750 \text{ Ft.} = 0.33 \text{ mi.}$

NORTH POOL STORAGE

STORAGE VOLUME = $V_{NP} = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$

$$\frac{1}{3} (15.51 + 16.53 + \sqrt{(15.51)(16.53)})$$

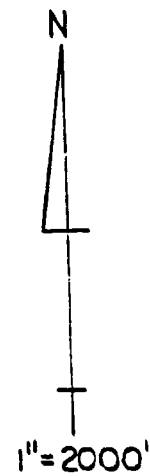
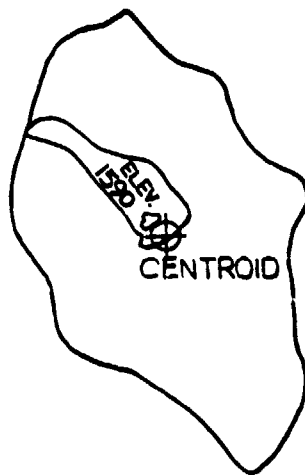
$$V_{NP} = 80.0 \text{ AC.-FT.}$$

TOP OF DAM STORAGE

$$V = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$$

$$= \frac{1}{3} (15.51 + 17.10 + \sqrt{(15.51)(17.10)})$$

$$V = 16.1 \text{ AC.-FT.}$$



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Subject WARNER DAM

S.O. No. 11

TOP OF DAM PROFILE AND

Sheet No. 3 of 10

TYPICAL CROSS SECTION

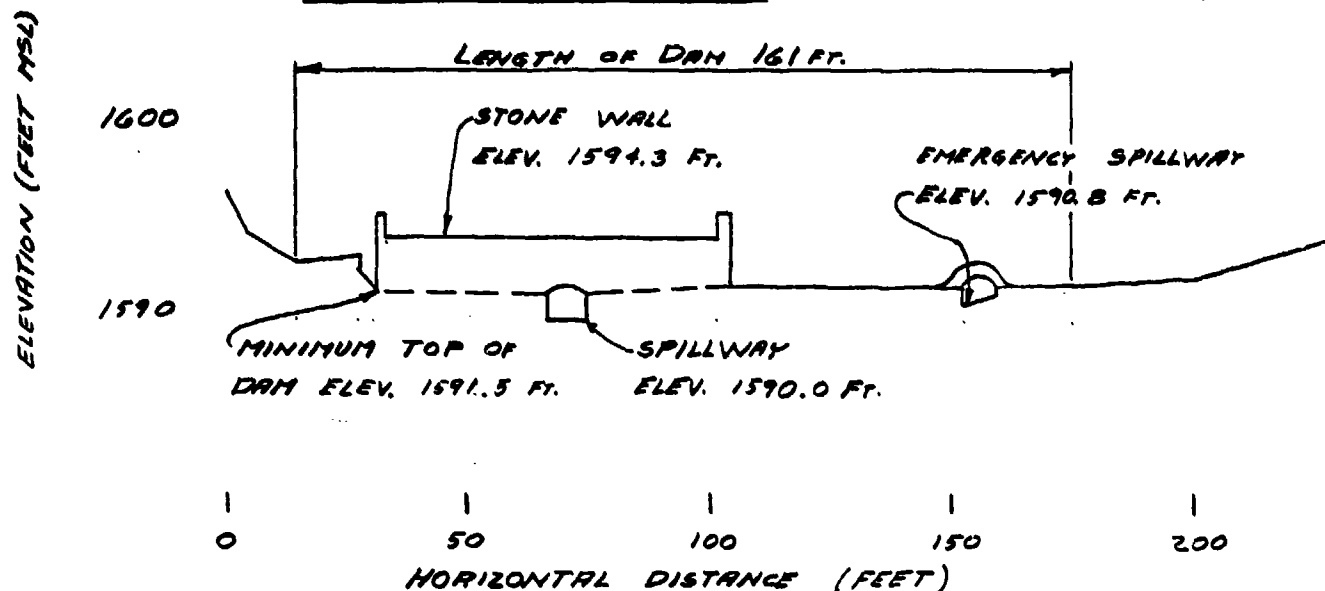
Drawing No.

Computed by GWT

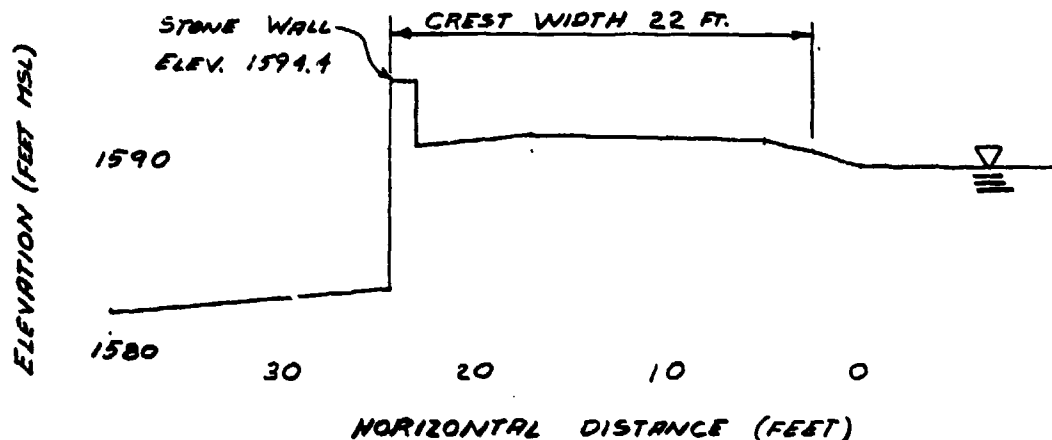
Checked by WDL

Date 3/30/91

TOP OF DAM PROFILE (LOOKING DOWNSTREAM)



TYPICAL CROSS SECTION @ SECTION A-A

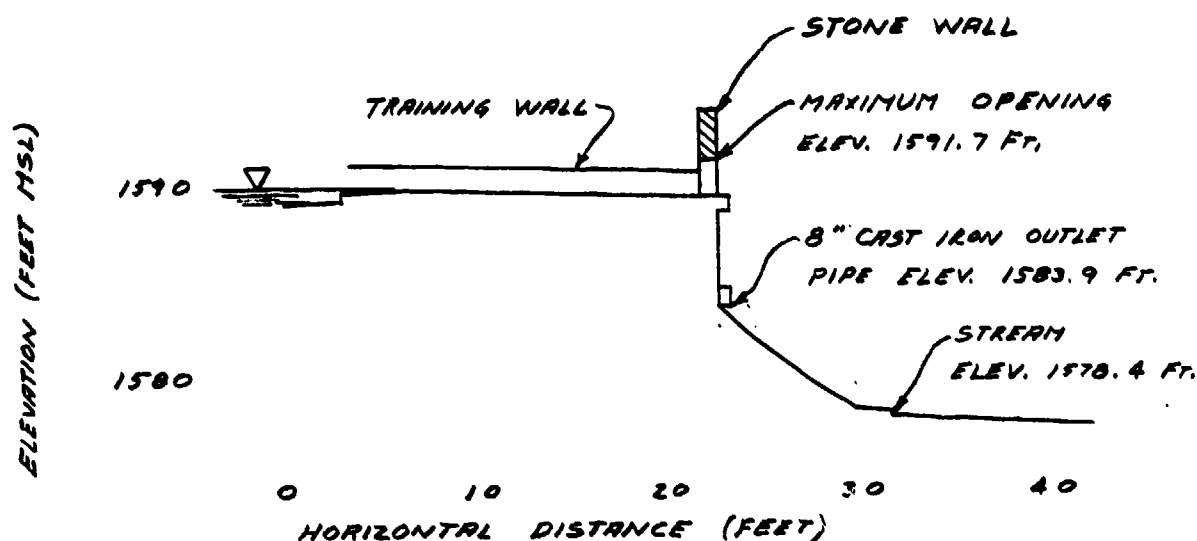


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Subject WARNER DAM S.O. No. 1
SPILLWAY DISCHARGE RATING Sheet No. 4 of 10
Drawing No.
Computed by GKT Checked by WGL Date 3/30/91

SPILLWAY PROFILE



DEVELOP RATING CURVE BASED UPON CRITICAL FLOW OVER SPILLWAY:

$$V = \sqrt{gD} \quad (\text{CHOW, OPEN CHANNEL HYDRAULICS, P. 43})$$

$$g = 32.2 \text{ FT/SEC}^2$$

$$D = \text{MEAN HYDRAULIC DEPTH} = \frac{\text{FLOW AREA}}{\text{FREE SURFACE TOPWIDTH}} = \frac{A}{T}$$

$$V = \text{MEAN VELOCITY}$$

SPILLWAY ELEV., (FT)	FLOW DEPTH, (FT)	AREA (FT ²)	TOP WIDTH, (FT)	A/T	V, (FT/SEC)	Q, (CFS)	$V/\sqrt{2g}$	RESERVOIR SURFACE, (FT)
1590.0	0	0	8.0	0	0	0	0	1590.0
1590.5	0.5	4.0	8.0	.5	4.01	16.0	.25	1590.75
1591.0	1.0	8.0	8.0	1.0	5.67	45.4	.50	1591.50
1591.3	1.3	10.4	8.0	1.3	6.47	67.3	.65	1591.95
1591.7								

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Subject: WARNER DAM S.O. No. 111
SPILLWAY DISCHARGE RATING Sheet No. 5 of 10
Drawing No.
Computed by GWT Checked by WDL Date 4/6/81

ORIFICE FLOW

$$Q = CA (2gH)^{.5}$$

$$Q = 73.04 H^{.5}$$

ELEV. (FT)	H (FT)	Q (CFS)
1592.5	1.7	95.2
1593.0	2.2	108.3
1593.5	2.7	120.0
1594.0	3.2	130.7
1594.5	3.7	140.5
1595.0	4.2	149.7
1595.5	4.7	158.3
1596.0	5.2	166.6

A = AREA RECTANGLE + AREA CIRCULAR SEGMENT

AREA CIRCULAR SEGMENT

$$R = 21.6 \text{ FT.}$$

$$\Delta = 22^\circ$$

$$A = \frac{\pi (21.6)^2 22}{360} - \frac{21.2 \times 8}{2}$$

$$A = 4.77 \text{ FT}^2$$

AREA RECTANGLE

$$A = 1.3 \times 8 = 10.4 \text{ FT}^2$$

$$\text{AREA} = 10.4 + 4.77 = 15.17 \text{ SQ. FT.}$$

$$g = 32.2 \text{ FT/SEC}^2$$

H VARIES FROM 1.7 FT. TO 5.2 FT.
AND IS MEASURED FROM CENTER OF AREA
C = .6 AVERAGE VALUE FROM
KING + BRATER

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Subject WARNER DAM

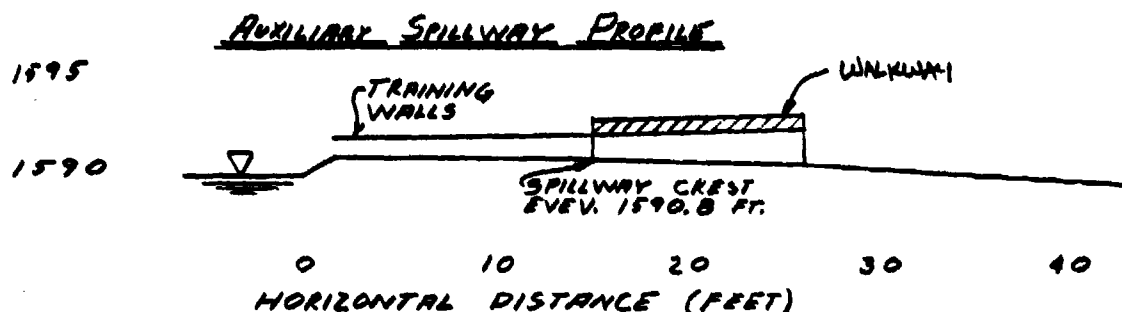
AUXILIARY SPILLWAY DISCHARGE RATING

S.O. No. 111

Sheet No. 6 of 10

Drawing No.

Computed by GLWT Checked by WDL Date 4/6/81



DEVELOP RATING CURVE BASED UPON CRITICAL FLOW OVER SPILLWAY CREST:

$$V = \sqrt{gD} \quad (\text{CHOW, OPEN CHANNEL HYDRAULICS, P. 43})$$

$$g = 32.2 \text{ FT/SEC}^2$$

$$D = \text{MEAN HYDRAULIC DEPTH} = \frac{\text{FLOW AREA}}{\text{FREE SURFACE TOP WIDTH}} = \frac{A}{T}$$

$$V = \text{MEAN VELOCITY}$$

$$Q = AV$$

SPILLWAY ELEV. (FT)	FLOW DEPTH, (FT)	AREA (FT ²)	TOP WIDTH (FT)	A/T	V, (FT/SEC)	Q (CFS)	V ^{3/2g}	RESERVOIR SURFACE, (FT)
1590.8	0	0	7.0	0	0	0	0	1590.8
1591.0	0.2	0.5	7.0	.07	1.50	0.7	.03	1591.03
1591.5	0.7	3.15	7.0	.45	3.81	12.0	.22	1591.72
1592.0	1.2	5.95	7.0	.85	5.23	31.1	.42	1592.42

ORIFICE FLOW

$$Q = CA(2gH)^{.5}$$

$$Q = 49.93 H^{.5}$$

$$A = 10.37 \text{ SQ. FT.}$$

$$C = .6 \text{ AVERAGE VALUE FROM BRATER + KING}$$

$$g = 32.2 \text{ FT/SEC}^2$$

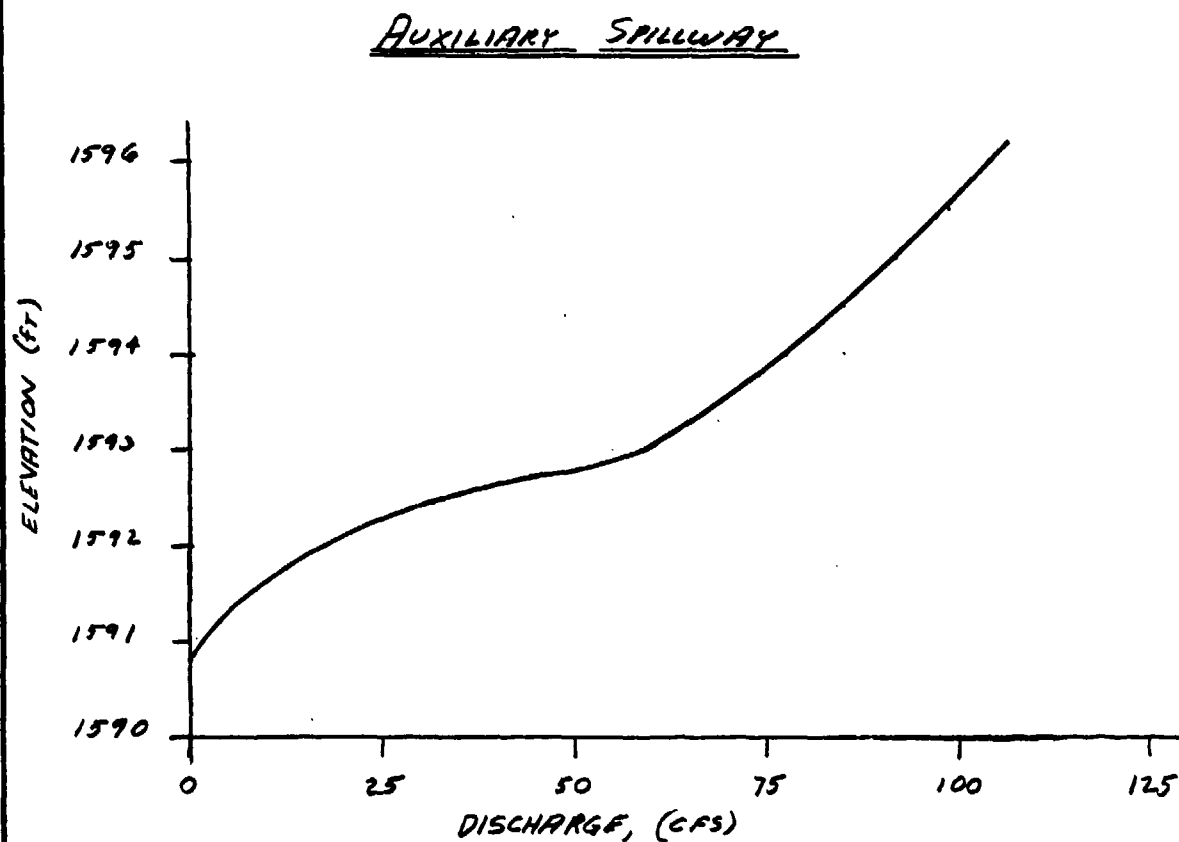
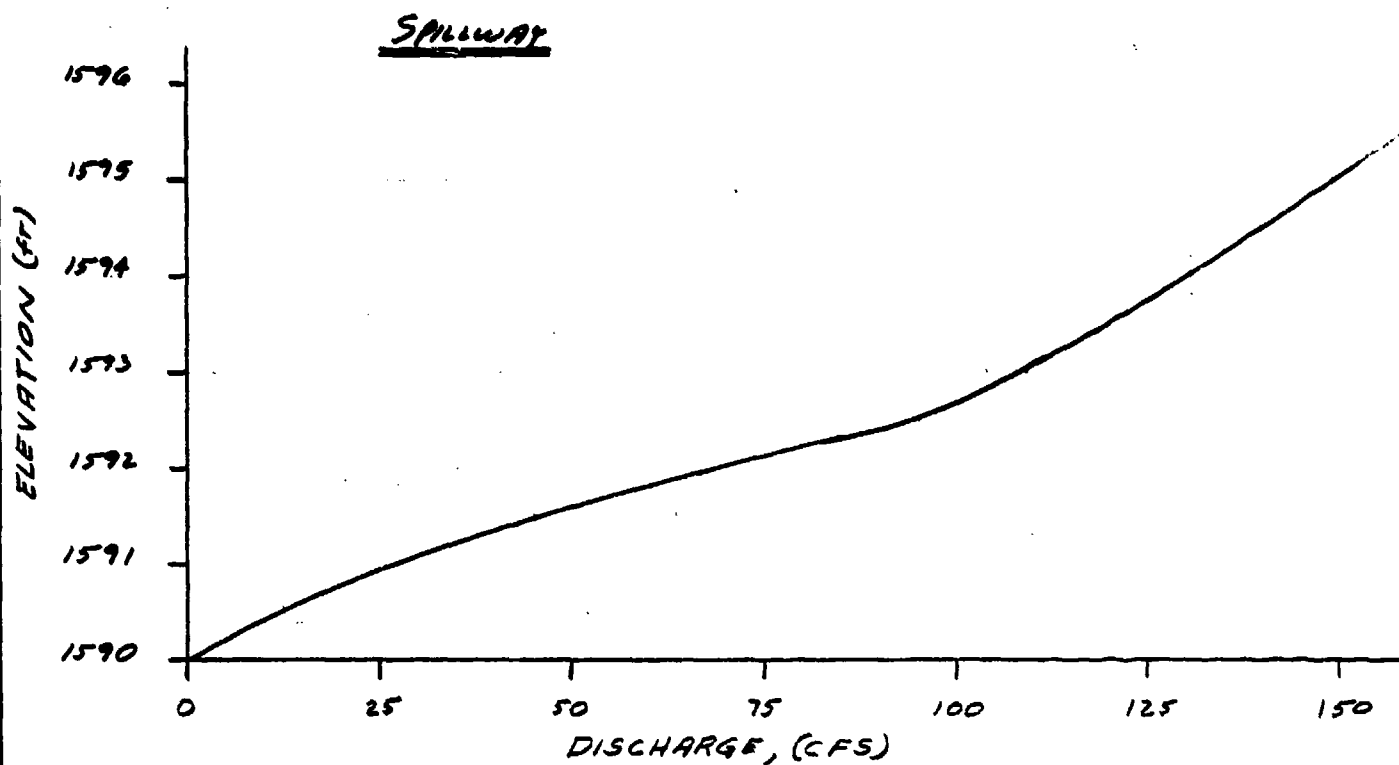
H VARIES FROM 1.4 FT TO 4.4 FT.
AND IS MEASURED FROM THE
CENTER OF THE AREA

ELEV. (FT)	H (FT)	Q (CFS)
1593.0	1.4	59.1
1593.5	1.9	68.8
1594.0	2.4	77.4
1594.5	2.9	85.0
1595.0	3.4	92.1
1595.5	3.9	98.6
1596.0	4.4	104.7

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Subject WARNER DAM S.O. No. 11
SPILLWAY RATING CURVES Sheet No. 7 of 10
Drawing No. _____
Computed by GWT Checked by WDL Date 7/29/01



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Subject WARNER DAM S.O. No. 1
SPILLWAY DISCHARGE RATING Sheet No. B of 10
SUMMARY Drawing No.
Computed by GWT Checked by WDC Date 4-6-81

SPILLWAY DISCHARGE SUMMARY

ELEVATION (FT)	SPILLWAY (Q)	AUXILIARY SPILLWAY (Q)	TOTAL (Q)
1590.0	0	0	0
1590.5	10.0	0	10.0
1591.0	24.0	0.7	24.7
1591.5	45.5	6.0	51.5
1592.0	67.4	18.0	85.4
1592.5	95.2	31.0	126.2
1593.0	108.3	59.1	167.4
1593.5	120.0	68.8	188.8
1594.0	130.7	77.4	208.1
1594.5	140.5	85.0	225.5
1595.0	149.7	92.1	241.8
1595.5	158.3	98.6	256.9
1596.0	166.6	104.7	271.3

SPILLWAY CAPACITY AT THE MINIMUM TOP
OF DAM (1591.5 FT.) IS 51.5 C.F.S.

THE INFLOW TO THE IMPOUNDMENT FOR THE 100-YEAR FLOOD WAS CALCULATED USING MATERIAL FROM "THE HYDROLOGIC STUDY - TROPICAL STORM AGNES" PREPARED BY THE SPECIAL STUDIES BRANCH, PLANNING DIVISION, NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS, IN NEW YORK CITY.

DRAINAGE AREA - 0.34

① COMPUTE THE MEAN LOGARITHM

$$\text{LOG } (Q_m) = C_m + 0.75 \text{ LOG } A$$

$\text{LOG } (Q_m)$ = MEAN LOGARITHM OF ANNUAL FLOOD PEAKS
 A = DRAINAGE AREA, SQ. MI. = 0.34
 C_m = MAP COEFFICIENTS FOR MEAN LOG OF ANNUAL PEAKS FROM FIG. 21 - 2.20

$$\begin{aligned}\text{LOG } (Q_m) &= 2.20 + 0.75 (\text{LOG } 0.34) \\ &= 1.8486\end{aligned}$$

② COMPUTE STANDARD DEVIATION

$$S = C_s - 0.05 (\text{LOG } A)$$

S = STANDARD DEVIATION OF THE LOGARITHMS OF THE ANNUAL PEAKS.

C_s = MAP COEFFICIENT FOR STANDARD DEVIATION FROM FIG. 22 = 0.35

A = DRAINAGE AREA, SQ. MI., = 0.34

$$\begin{aligned}S &= 0.350 - 0.05 (\text{LOG } 0.34) \\ &= 0.3734\end{aligned}$$

③ SELECT SKEW COEFFICIENT FROM FIG. 23 = 0.225

$$\text{LOG } (Q_{100}) = \text{LOG } (Q_m) + K(P, g) S$$

$K(P, g)$ = STANDARD DEVIATE FOR A GIVEN EXCEEDENCE FREQUENCY PERCENTAGE (P) AND SKEW COEFFICIENT (g) FROM EXHIBIT 39 OF BEARD'S "STATISTICAL METHODS IN HYDROLOGY"

$$\begin{aligned}\text{LOG } (Q_{100}) &= 1.8486 + 2.50 (0.3734) \\ Q_{100} &= 605 \text{ CFS}\end{aligned}$$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject WARNER DAM S.O. No. _____
100-YEAR DISCHARGE CALCULATION Sheet No. 10 of 10
Drawing No. _____
Computed by GWT Checked by WDL Date 7/8/81

THE INFLOW TO THE IMPOUNDMENT FOR THE 100-YEAR FLOOD WAS CALCULATED USING MATERIAL FROM "WATER RESOURCES BULLETIN, BULLETIN NO. 13, FLOODS IN PENNSYLVANIA", PREPARED BY THE DEPARTMENT OF ENVIRONMENTAL RESOURCES, COMMONWEALTH OF PENNSYLVANIA.

DRAINAGE BASIN FROM PLATE 1 - MODEL 1
REGRESSION EQUATION FROM TABLE

$$Q_T = CA^X S^Y$$

$$T = 100 \text{ YEARS}$$

$$C = 14.3$$

$$A = \text{DRAINAGE AREA, } 0.34 \text{ SQ. MI.}$$

$$X = 1.045$$

$$Y = .477$$

$$Q_{100} = 14.3(0.34)^{1.045}(175)^{0.477}$$

$$Q_{100} = 54.4 \text{ C.F.S.}$$

$$L = 4,750 \text{ FT.}$$

$$\text{ELEV.} = 1,800 \text{ FT.} - 1,590$$

$$\text{ELEV. DIFFERENCE} = 210$$

$$\text{ELEV. } 85\% \text{ OF WATERSHED} = 1768.5 \text{ FT.}$$

$$\text{ELEV. } 10\% \text{ OF WATERSHED} = 1611 \text{ FT.}$$

$$S = \frac{1768.5 - 1611}{4750} \times 5280 = 175 \text{ FT/MILE}$$

AVERAGING THE INFLOW FROM THIS METHOD AND THE PREVIOUS METHOD GIVES AN INFLOW OF 329 C.F.S. TO THE IMPOUNDMENT.

APPENDIX E

PLATES

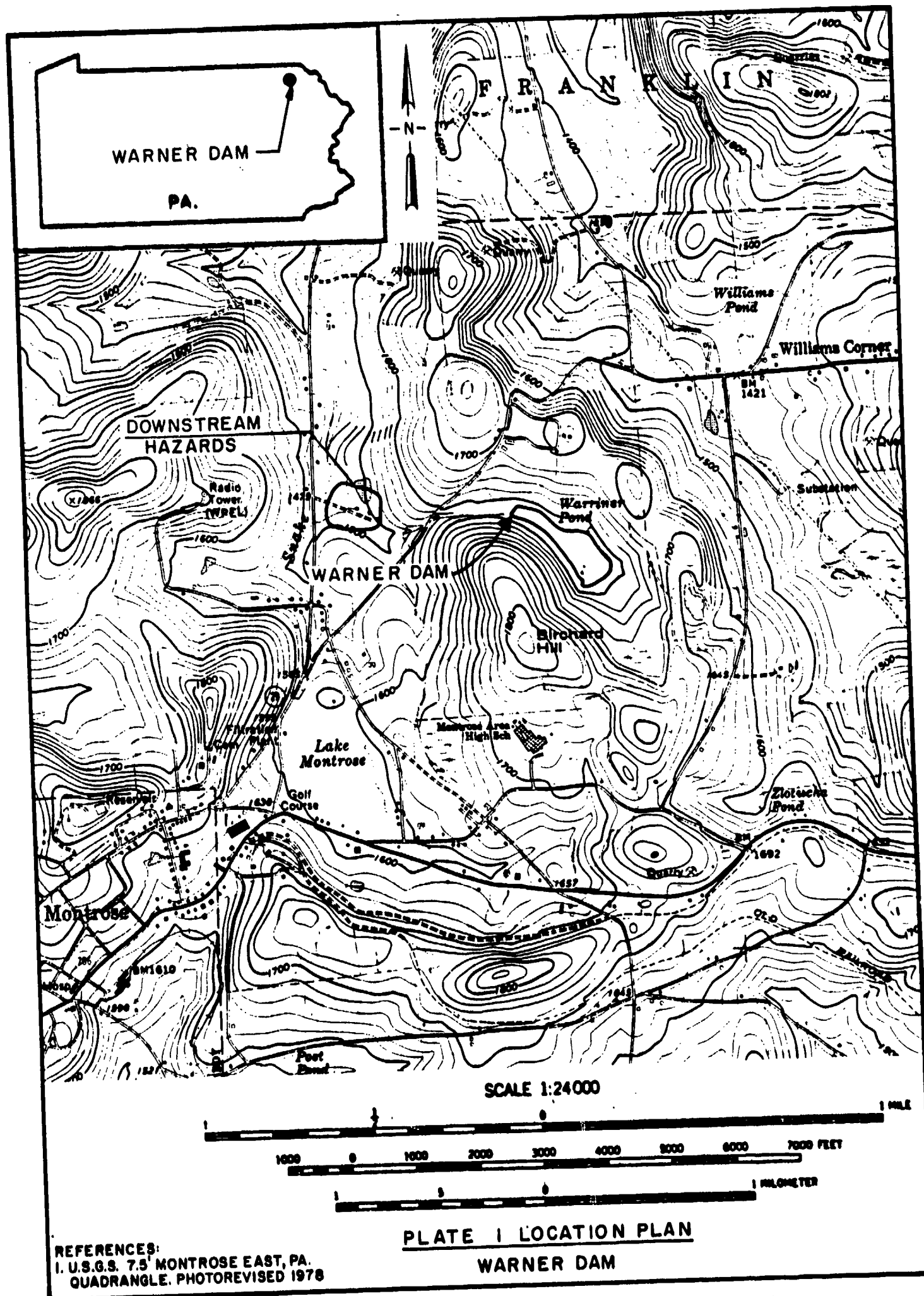
CONTENTS

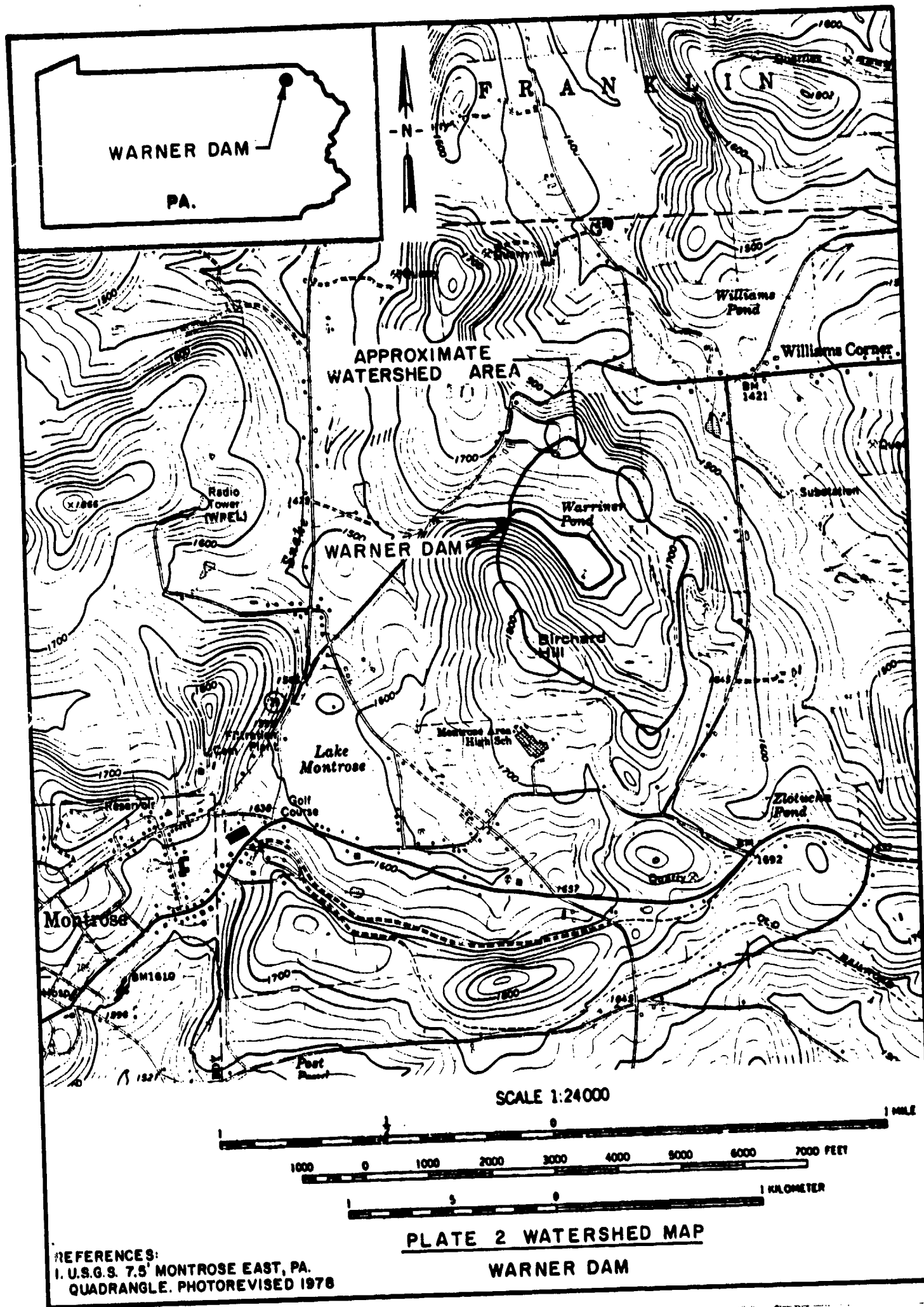
Plate 1 - Location Plan

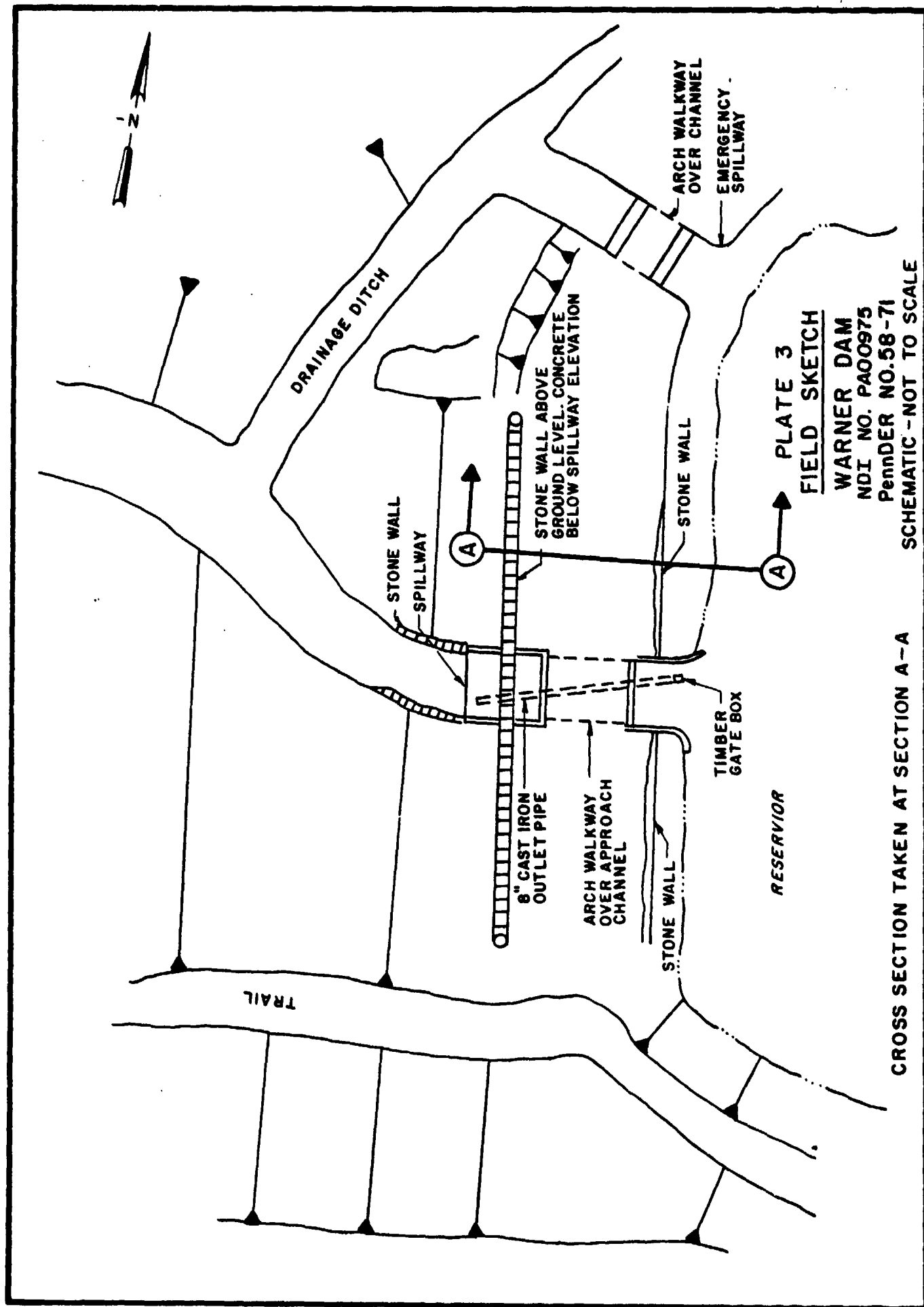
Plate 2 - Watershed Map

Plate 3 - Field Sketch from Visual Inspection

Plate 4 - Top of Dam Profile and Typical Cross-Section from
Visual Inspection







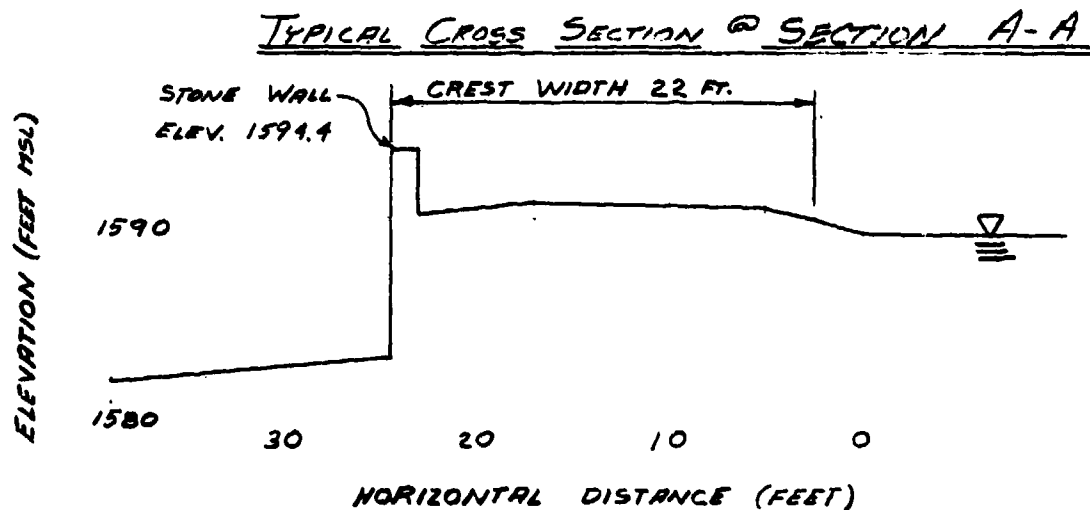
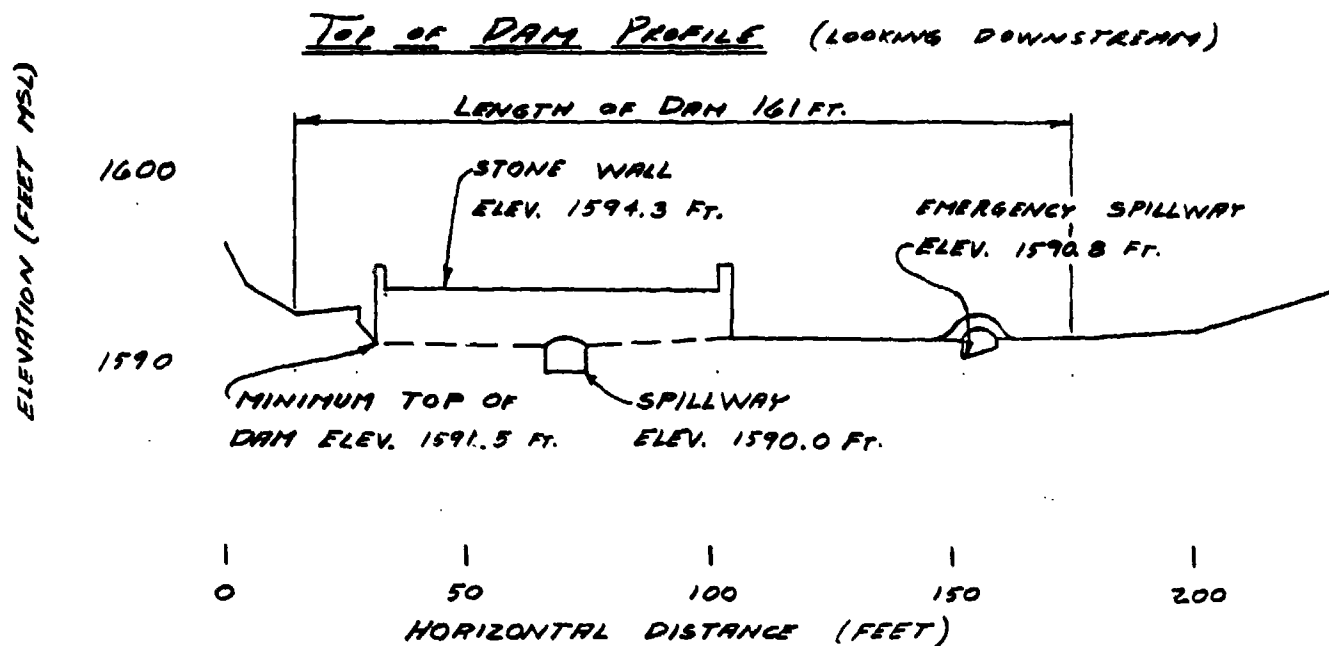
CROSS SECTION TAKEN AT SECTION A-A

PLATE 3
 FIELD SKETCH
 WARNER DAM
 NDI NO. PA00975
 PENNDER NO.58-71
 SCHEMATIC -NOT TO SCALE

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Beaver, Pa. 15009



APPENDIX F
REGIONAL GEOLOGY

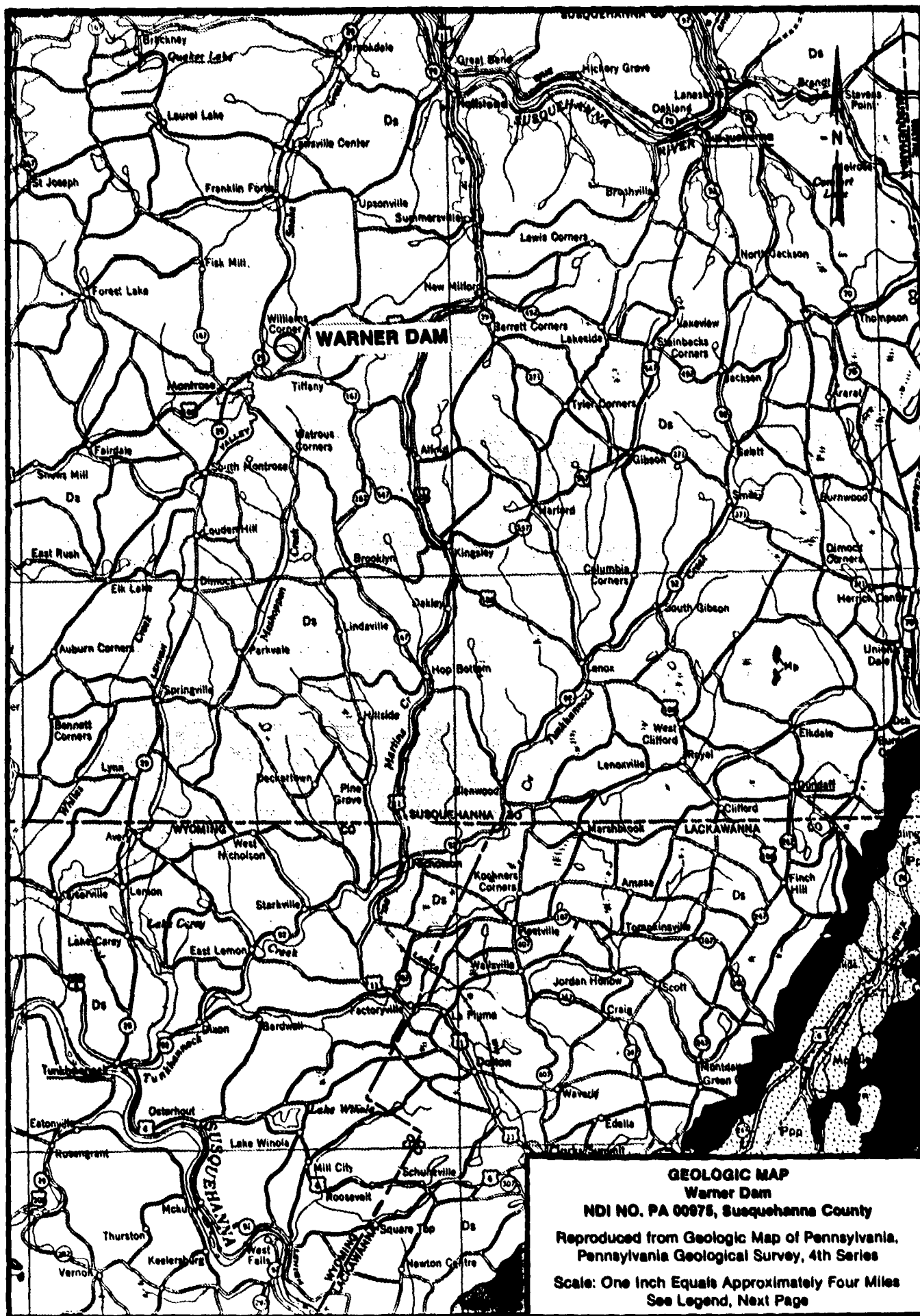
Warner Dam
NDI No. PA 00975, PennDER No. 58-71

REGIONAL GEOLOGY

The Warner Dam is located in the glaciated northeast section of the Appalachian Plateaus physiographic province. The dam occupies the middle of an unnamed stream valley draining to Snake Creek. Snake Creek in turn drains to the Susquehanna River. The maximum topographic relief in the Warner pond stream valley is 340 feet.

The study area has been glaciated at least three times and is presently overlaid by glacial ground moraine of the Nebraskan, Kansan, and Wisconsin glaciations. No test boring information was available for review; thus, the extent and thickness of the soil types are difficult to ascertain. According to the Soil Conservation Service survey for Susquehanna County, soils in the vicinity of the dam consist of stoney and channery silt loams of the Morris-Wellsboro-Volusia association.

Geologic data taken from the Geologic Map of Pennsylvania indicate that the bedrock in the vicinity of the dam is composed of rocks which belong to the Devonian-Susquehanna Group. Rocks belonging to this group have been subdivided, in other sections of the state, into the Marine Beds, the Catskill Formation and the Oswayo Formation. The rocks underlying the dam most likely belong to the Catskill Formation. This formation is composed chiefly of red to brownish shales and sandstones, including gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River in the East.



GEOLOGY MAP LEGEND

DEVONIAN UPPER

WESTERN PENNSYLVANIA



Oswayo Formation

Greenish gray to gray shales, siltstones and sandstones becoming increasingly shaly westward; considered equivalent to type Oswayo, Riceville Formation D₁ in Erie and Crawford Counties; probably not distinguishable north of Curry.



Cattaraugus Formation

Red, gray and brown shale and sandstone with the proportion of red decreasing eastward; includes Venango sands of drillers and Salamanca sandstone and conglomerate; some limestone in Crawford and Erie counties.



Conneaut Group

Alternating gray, brown, greenish and purplish shales and siltstones; includes "pink rock" of drillers and "Chemung" and "Girard" Formations of northwestern Pennsylvania.



Canadaway Formation

Alternating brown shales and sandstones; includes "Portage" Formation of northwestern Pennsylvania.

CENTRAL AND EASTERN PENNSYLVANIA



Oswayo Formation

Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Oswayo not proved.



Catskill Formation

Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone lenses named Elk Mountain, Honesdale, Shokola, and Delaware River in the east.



Marine beds

Gray to olive brown shales, graywackes, and sandstones, contains "Chemung" beds and "Portage" beds including Buckel, Bratler, Harrell, and Trimmera Rock; Tully Limestone at base.



Susquehanna Group

Barbed line in "Chemung-Catskill" contact of Second Pennsylvania Survey County reports; barbs on "Chemung" side of line.

MIDDLE AND LOWER



Hamilton Group



Mahantango Formation

Brown to olive shale with interbedded sandstones which are dominant in places (Montebello); highly fossiliferous in upper part; contains "Centerfield coral bed" in eastern Pennsylvania.



Marcellus Formation

Black, fossil, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.



Onondaga Formation

Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Schuylburg Limestone and Needmore Shale in central Pennsylvania and Butterfield Falls Limestone and Knappa Shale in easternmost Pennsylvania; in Lehigh Gap area includes Palmerton Sandstone and Rowmantown Chert.



Oriskany Formation

White to brown, fine to coarse grained, partly calcareous, locally conglomeratic, fossiliferous sandstone (Ridgely) at the top; dark gray, cherty limestone with some interbedded shales and sandstones below (Shriver).



Helderberg Formation

Dark gray, calcareous, thin bedded shale (Mandata) at the top, equivalent to Port Ewen Shale and Becraft Limestone in the east; dark gray, cherty, thin bedded, fossiliferous limestone (New Scotland) with some local sandstones in the middle; and, at the base, dark gray, medium to thick bedded, crystalline limestone (Cochran) sandy and shaly in places with some chert nodules.